Distribution and habitat requirements of the Yellow-footed Antechinus *Antechinus flavipes* at multiple scales: a review

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Abstract
This review synthesises present knowledge of the distribution patterns and habitat requirements of the Yellow-footed Antechinus *Antechinus flavipes*. Factors influencing the distribution of *A. flavipes* are examined at several spatial scales ranging from the broad climatic conditions prevalent over the species' entire range to the characteristics of nest sites used by individual animals. Analysis of the literature suggests that: 1) at the broad-scale, *A. flavipes* distribution is largely determined by warm, dry climatic conditions, the distribution of dry forests and woodlands and competition with closely related species; 2) at the landscape-scale the determinants of *A. flavipes* distribution are largely unknown, although initial investigations suggest some tolerance of fragmented landscapes; and 3) at a local-scale the distribution of *A. flavipes* is largely determined by the presence of large diameter trees, tree hollows, coarse woody debris, rocky crevices and leaf-litter. Directions for future research are suggested throughout the review. (*The Victorian Naturalist* **123** (2), 2006, 91-100)

Introduction

In a few short years I have noted its final disappearance from areas where formerly it was possible to watch the bright-eyed little fellows running a few feet at a time along sun-bleached logs, stopping with a characteristic jerk and as quickly moving sideways, forwards, or circling a tree trunk in their own inimitable style. (David Fleay, 1949)

The Yellow-footed Antechinus *Antechinus flavipes* is a small dasyurid marsupial that occurs in a wide range of habitats across southern and eastern Australia (Van Dyck 1998). Knowledge of the habitat requirements of *A. flavipes* is limited, and much of its range corresponds with cleared and degraded temperate forest and woodland (Menkhorst 1995; van der Ree 2003). Consequently, the conservation of the species throughout much of its range may not be assured (Menkhorst 1995). Given that an understanding of the variables that influence the distribution of a species is essential for effective conservation-based management (Austin 2002; Gibson *et al.* 2004a), research into the habitat requirements of *A. flavipes* should be an imperative.

This review synthesises present knowledge of the distribution patterns and habitat requirements of *A. flavipes*. The two southern subspecies, *A. f. flavipes* and *A. f.*

leucogaster, are the focus of the review as little has been published about the ecology of the north-east Queensland subspecies *A. f. rubeculus*. Beginning with a brief introduction to the life history and ecology of *A. flavipes*, I then highlight the importance of analysing the distribution of a species at multiple spatial scales. The distribution of *A. flavipes* is then examined at the broad-scale, landscape-scale and local-scale, and previous research on this species and its congeners is discussed. After indicating directions for future research throughout the review, I conclude with examples of experimental design that may be useful in furthering our understanding of the distribution and habitat requirements of *A. flavipes.*

Life history and ecology

A. flavipes is a small (20-75 g), semi-arboreal species (Smith 1984; Dickman 1991; Marchesan and Carthew 2004). Invertebrates are the main source of food, with nectar and small vertebrates taken opportunistically (Fleay 1949; Menkhorst 1995; Goldingay 2000). Although many populations are thought to be nocturnal (Wakefield and Warneke 1967; Van Dyck 1998), diurnal activity has been observed in Victorian populations (Coates 1995; Menkhorst 1995). The average home range

of *A. flavipes* in dry forest in Victoria has been estimated to be 1.2 ha for males and 0.78 ha for females, using a grid-capture based method (Coates 1995).

The life-history of *A. flavipes* involves a brief mating period between June and September, the subsequent mortality of all males in the population following mating and the production of one litter of 8-14 young each year (Lee *et al.* 1982; Van Dyck 1982; Smith 1984; Marchesan and Carthew 2004). Although breeding is highly synchronised within local populations (Dickman 1980; Van Dyck 1982), breeding times between populations have been found to vary with latitude, climate and the timing of peaks in invertebrate abundance (Van Dyck 1982; Smith 1984).

Recent studies suggest that *A. flavipes* follows a male-biased dispersal strategy, with males dispersing from natal areas following weaning, and females remaining philopatric (Marchesan and Carthew 2004). Occurring at lower densities than other Antechinus species (Dickman 1980), population densities of *A. flavipes* have been estimated at between 0.11 to 4.17 individuals per hectare (Reeckman 1975 cited in Dickman 1980; Smith 1984; Watt 1997).

Spatial scale

A wide range of factors influence the distribution patterns of species, including abiotic processes (e.g. climate), biologically mediated processes (e.g. physiology) and processes governed by biotic interactions (e.g. competition) (Krebs 2001; Mackey and Lindenmayer 2001). The distribution patterns that we observe, and the processes that determine these patterns, can change with the spatial scale of investigation or observation (Wiens 1989; Levin 1992; Cooper *et al.* 1998; Luck 2002a). Consider the following example.

In the Central Highlands of Victoria, the presence of Leadbeater's Possum *Gymnobelideus leadbeateri* at the broad-scale is determined by the presence of ash-type forest and a narrow range of climatic conditions (Lindenmayer 2000). At the landscape-scale the species was found to inhabit large forest blocks, with distribution determined by past disturbances such as logging and fire (Lindenmayer 2000).

At the local-scale the species was found to inhabit forest areas with numerous large trees, hollows and an understorey of Acacia species (Lindenmayer 2000). Preferred nest-trees had large diameter stems, were highly decayed, contained numerous cavities and were surrounded by a dense understorey (Lindenmayer 2000).

Spatial scale can be defined by two components that define the upper and lower limits of a study: extent is the overall area encompassed by a study and grain is the smallest unit of observation (Wiens 1989; Mayer and Cameron 2003). The above example highlights the importance of studying species at multiple spatial scales because investigations undertaken at only one spatial scale may fail to explain or observe important patterns and processes. For instance, by varying the extent of investigations from forest patches at a landscape-scale to the entire range of the species at a broad-scale, Lindenmayer (2000) was able to uncover the narrow range of climatic conditions that *G. leadbeateri* inhabits. Further, by varying the grain of investigations from the characteristics of habitat patches to the characteristics of individual trees, Lindenmayer (2000) was able to determine the features of preferred nest sites of *G. leadbeateri*.

Additionally, multiple scale analysis allows for diverse management strategies to be implemented, because each spatial scale of investigation often has a corresponding scale of management (Lindenmayer and Franklin 2002; Wiens *et al.* 2002). For instance, investigations at broad-scales correspond with the management of entire regions, whereas investigations at landscape-scales relate well to the management and implementation of protected areas and wildlife corridors (Lindenmayer 2000).

Considering the importance of studying species at multiple scales, the distribution of *A. flavipes* will be examined at three spatial scales: the broad-scale, the landscape-scale and the local-scale.

Broad-scale distribution

A. flavipes occurs in eastern and south-western Australia in a wide range of habitats including dry forest, tropical vine forest, swampy forest, dry woodland and

heathy woodland (Van Dyck 1982, 1998; Menkhorst 1995). Three subspecies are currently recognised: *A. f. flavipes* occurs in southern Queensland, New South Wales, Victoria and South Australia; *A. f. rubeculus* occurs in north-eastern Queensland; and *A. f. leucogaster* occurs in south-western Western Australia (Van Dyck 1998). However, the taxonomic status of some populations is still in doubt (Crowther *et al.* 2002; How *et al.* 2002). For example, in south-western Australia, northern populations of *A. flavipes* are characterised by females that have ten nipples, while geographically separated southern populations are characterised by females with eight nipples (How *et al.* 2002). This suggests variation in reproductive potential and possible taxonomic differences between populations (How *et al.* 2002).

Although found in a variety of habitats, site location records indicate that the broad-scale distribution of *A. flavipes* is closely associated with the dry sclerophyll forests and woodlands predominant on the inland slopes of the Great Dividing Range and in south-western Western Australia (Wardell-Johnson 1986; Menkhorst 1995; Van Dyck 1998). For example, Victorian populations of *A. flavipes* are closely associated with dry forest, dry woodland and heathy woodland vegetation communities that run in a diagonal band through the centre of the state from the south-west to the north-east (Menkhorst 1995).

Fifty per cent of *A. flavipes* populations in Victoria occur in the Box-Ironbark region (ECC 1997), with other populations present in the Wannon and Grampians regions (Menkhorst 1995). *Antechinus flavipes* is generally uncommon, although not threatened, but is likely to play a significant ecological role in habitats such as box-ironbark forest and floodplain forest where it is one of few (or often the only) predominant native small-mammal species (ECC 1997; Mac Nally and Horrocks 2002). For example, Mac Nally and Horrocks (2002) suggested *A. flavipes* is likely to have a considerable influence on invertebrate populations of River Red Gum floodplain forest.

The climate analysis program BIOCLIM has been used to predict the broad-scale distribution of *A. flavipes* based on the cli-matic conditions of known site locations (see Sumner and Dickman 1998; Crowther 2002; Crowther *et al.* 2002). *Antechinus flavipes* was predicted to occur predomi-nantly in warm, inland areas of south-east-ern Australia with a mean annual tempera-ture of 14.5 °C and a mean annual rainfall of 785 mm (Crowther 2002). The core pre-dicted distribution followed the inland slopes of the Great Dividing Range, with a patchy distribution predicted for coastal and inland areas. *A. flavipes* was also pre-dicted to occur in coastal areas of southern New South Wales and eastern Victoria, where there are no records of the species' occurrence, and to have a much greater range inland than is currently recognised (Sumner and Dickman 1998; Crowther 2002). Few location records exist from semi-arid inland regions (although see Ellis and Smith 1990). *A. flavipes* was predicted to occupy wetter, more variable environ-ments in south-western Australia than in eastern Australia (Crowther *et al.* 2002).

Crowther (2002) examined the distribu-tion of *A. flavipes* in relation to those of the Brown Antechinus *A. stuartii*, Agile Antechinus *A. agilis* and Subtropical Antechinus *A. subtropicus*, and found sub-stantial differences in the climatic indices that determined each species's distribution. The predicted range for *A. flavipes* includ-ed areas with the lowest mean annual pre-cipitation (an arid 282 mm) and the lowest annual mean moisture index (0.6) of the four species. This reflected the high evapo-ration rates within the species's range, and its tolerance of much drier, less predictable environments than other Antechinus species (Crowther 2002). The broader dietary niche of *A. flavipes*, indicated by dental and cranial characteristics which allow it to feed on a large range of prey, may explain its occurrence in a diverse range of habitats and its ability to survive in more unpredictable, drier environments than its congeners (Van Dyck 1982; Coates 1995).

The limited sympatry between *A. flavipes* and its congeners (Sumner and Dickman 1998) and the tendency of *A. flavipes* to be restricted to dry forest and woodland yet occur in wet forest when *A. stuartii* is absent (Van Dyck 1982), suggests that competition may influence its distribution

at the broad-scale. Furthermore, bioclimatic analysis indicates that *A. flavipes* is absent from large areas of climatically suitable habitat. In these areas the presence of the Dusky Antechinus *A. swainsonii* and *A. agilis* could be limiting its distribution (Crowther 2002). The limited sympatry that does exist between *A. flavipes* and its congeners generally occurs at the margins of the species' range, for example with *A. agilis* in the eastern highlands of Victoria (Menkhorst 1995), and has been attributed to a distribution undergoing change or the presence of an ecotone (Van Dyck 1982).

Undoubtedly a range of factors not discussed here, such as soil, geology and altitude, also influence the distribution of *A. flavipes* at the broad-scale, and interact with the major factors discussed. However, the literature suggests that at the broad-scale *A. flavipes* is most influenced by the climatic parameters highlighted, broad vegetation patterns and competition with closely related species.

Future research into the distribution of *A. flavipes* at the broad-scale should focus on:
• surveying regions where *A. flavipes* was bioclimatically predicted to occur, but has not been verified by site records;
• taxonomic studies to clarify the level of similarity or difference between currently recognised subspecies and populations within these subspecies.

Landscape-scale distribution

Disturbances such as fire, flood and drought have long influenced the evolution of the Australian mammal fauna, but the advent of European settlement saw the type, scale, frequency and intensity of these disturbances change, and the addition of new disturbances such as vegetation clearance and habitat fragmentation (Wilson and Friend 1999). Despite altered disturbance regimes and habitat loss being recognised as a major threat to the Australian mammal fauna (Wilson *et al.* 2003), little information is available on the effects of these disturbances on *A. flavipes*.

In a study of *A. flavipes* in a fragmented landscape in South Australia, Marchesan and Carthew (2004) found that individuals that occurred in larger forest patches weighed less and occurred in lower population densities than those inhabiting smaller patches and strips of remnant vegetation. These differences, and successful reproduction in the area, suggest a tolerance by *A. flavipes* of fragmented landscapes and possible favourable responses to edge habitat (Marchesan and Carthew 2004). They suggest that the life-history strategy of *A. flavipes* allows the species to persist in fragmented areas because the complete male die-off after the breeding season leaves increased resources for lactating females and emerging young, with small populations then replenished by male dispersal following weaning. Tolerance of fragmented habitat was also reported in north-eastern Queensland by Laurance (1994) who found that *A. flavipes* was more abundant in rainforest fragments than in continuous rainforest. Additionally, 11 of 14 individuals were captured within 35 m of forest edges (Laurance 1994).

In north-eastern Victoria, van der Ree (2003) demonstrated that *A. flavipes* can successfully reproduce in a fragmented landscape. However, far from finding favourable responses to edge habitat, an absence of *A. flavipes* in 90% of linear habitat indicated limited tolerance to fragmentation in this area. The absence of the species was suggested to be a consequence of reduced quality of habitat and increased predation in remnant linear strips and patches (van der Ree 2003). Large diameter trees probably contributed to the persistence of the species in the rare sections of linear habitat where they were present (van der Ree 2003).

The ability of *A. flavipes* to move between remnant habitat patches across heavily disturbed areas remains largely unknown, although some incidental records are available. Dickman (1991) reported the species foraging 100 m from the nearest tree in open pasture, adjacent to open forest, in New South Wales. Additionally, relatively large movements of 1100 m and 700 m have been recorded (Dickman 1986; van der Ree 2003). Van der Ree (2003) suggested that the ability of *A. flavipes* to move through disturbed areas may be the reason it can remain in some fragmented landscapes. This was demonstrated by Marchesan and Carthew (2004) who recorded *A. flavipes* moving up to 720 m between remnant vegetation patches.

Fire is a major disturbance factor and plays an important role in shaping the Australian landscape (Wilson and Friend 1999). Altered fire regimes may have caused substantial declines in mammal species (Wilson *et al.* 2003). The response of small mammals to fire regimes has received considerable attention in the published literature (see Wilson *et al.* 1990; Wilson *et al.* 2001; Friend 2004), although little is known for *A. flavipes*.

Christensen and Kimber (1975) studied the effects of fuel reduction burning on sclerophyll forest in south-western Western Australia. In both wet and dry sclerophyll forest *A. flavipes* occurred mostly in areas where fire was excluded, and was rare in recently burnt areas. For instance, in wet sclerophyll forest that had remained unburnt for 40 years, the trapping rate was 7.41 individuals per 100 trap nights. In areas that had been burnt five and 20 years previously, trapping rates were less than 0.5 individuals per 100 trap nights (Christensen and Kimber 1975). Post-fire mortality was high as indicated by trapping rates of 1.91 per 100 trap nights before a burn and trapping rates of 0.23 per 100 trap nights 19 months after a burn (Christensen and Kimber 1975). Conversely, Thompson *et al.* (1989) indicated that fire had little or no effect on *A. flavipes* in dry sclerophyll forest in South Australia, with the survival and persistence of the small study population following a low intensity fuel reduction burn.

Other disturbances such as floods and drought may also influence the species's distribution. For example, Mac Nally and Horrocks (2002) highlighted that *A. flavipes* habitat in River Red Gum forests and woodlands in the Riverina region of Victoria regularly floods, with a likely outcome being large changes in the abundance of invertebrates and shelter sites.

Future research into the distribution of *A. flavipes* at the landscape-scale should focus on:

• the effects of habitat loss and fragmentation on the species (How large do remnant patches need to be to provide suitable habitat? Does the species respond more strongly to the structural components of remnant patches or patch size? Can linear patches and corridors provide a conduit for movement of the species between patches? Can habitat corridors provide resident habitat? Is an agricultural matrix a substantial barrier to movement?)
• metapopulation dynamics
• the long-term effects of disturbance regimes on the species. (What are the effects of fire intensity, season and frequency on the species? What are the effects of flooding in riparian habitats? What are the effects of drought?)

Local-scale distribution

Antechinus flavipes has a wide geographic distribution across a variety of vegetation types (Van Dyck 1998), which suggests that at local scales habitat components other than floristic composition may be of greater importance in determining its presence. Several studies have highlighted the importance of a number of habitat structural components in influencing the species's presence.

In a study analysing foraging behaviour and habitat use of small-mammals in southern Queensland, Stokes *et al.* (2004) revealed preferences of *A. flavipes* for microhabitats that were structurally complex. Using artificially placed netting, and by manipulating food availability, *A. flavipes* was found to forage most frequently where both logs and rock crevices were present, with tree and understorey cover found to be less important indicators (Stokes *et al.* 2004). The authors suggested that *A. flavipes* may perceive structurally complex habitats as having a lower predation risk, but also indicate that rocks and logs provide individuals with food, nest sites and shelter from the elements (Stokes *et al.* 2004).

The loss of structural complexity may be detrimental to populations of *A. flavipes*, as individuals may be forced to forage in more exposed areas, with higher predation rates a likely outcome (Stokes *et al.* 2004).

Studies undertaken in the Riverina region of Victoria have highlighted the positive relationship between *A. flavipes* and coarse woody debris, by manipulating wood loads at a number of sites (Mac Nally *et al.* 2001; Mac Nally and Horrocks 2002). Densities of *A. flavipes* were found to rise to significantly higher levels as wood den-

sites reached >20 t/ha (Mac Nally and Horrocks 2002) and >45 t/ha (Mac Nally *et al.* 2001). Again, the shelter and food provided by the coarse woody debris were suggested as reasons for the association (Mac Nally and Horrocks 2002). This research also indicated the type of coarse woody debris favoured by *A. flavipes*. The species only responded positively to coarse woody debris in the form of logs or large boughs, as opposed to 'tree crowns' which failed to attract the species (Mac Nally and Horrocks 2002).

Large diameter trees are another important habitat component for *A. flavipes*. Dickman (1991) found that *A. flavipes* principally foraged on the surface of large eucalypts and under the hanging bark that they produced in open forest in New South Wales and Western Australia. Large trees are also important because they are more likely to contain tree hollows, the key nesting site of the species (Dickman 1991; Trail 1991). Wardell-Johnson (1986) suggested that the availability of hollows, and therefore large diameter trees, was a limiting factor in the presence of the species.

A. flavipes has been recorded as using a range of hollows including crown hollows, stump hollows, coppice hollows and base hollows (Dickman 1991; Trail 1991; Coates 1995). Coates (1995) found that *A. flavipes* in dry forest in north-central Victoria used hollows close to the ground for communal nesting and hollows used for suckling young were located >2 m above the ground. This may be a strategy to avoid predators such as the Red Fox *Vulpes vulpes* and the Cat *Felis catus* while suckling young (Coates 1995).

A range of other nest-sites can also be used by the species. In dry heathland in South Australia, Marchesan and Carthew (2004) found that the majority of nest sites were in the crowns of *Xanthorrhoea semiplana tateana* (66%), with the remaining nest sites in tree hollows and stags. It is not known whether there was a preference for this species as a nesting site or whether it was due to its availability compared with other species (Marchesan and Carthew 2004). Rocky outcrops and rock crevices have also been recorded as providing nest-sites in Victoria and New South Wales (Fleay 1949; Dickman 1980, 1986).

Leaf litter is another important habitat component (Wardell-Johnson 1986). Christensen and Kimber (1975) reported that *A. flavipes* in dry sclerophyll forest in Western Australia favoured areas with a deep litter layer, with at least the first few centimetres of the ground layer consisting of dead material. Further, in another Western Australian study, Sawle (1979 cited in Wardell-Johnson, 1986) found that the highest number of *A. flavipes* were in structurally complex sites with distribution primarily related to litter depth. Leaf litter is thought to be a good indicator of the quantity of invertebrates, the main food source of *A. flavipes* (Wardell-Johnson 1986) Coates (1995) reported that 92% of telemetry observations placed male *A. flavipes* within 2 m of the ground, highlighting considerable use of the ground layer.

Although leaf litter is an important habitat component in some areas, it may not be true of all areas inhabited by *A. flavipes*. Wardell-Johnson and Nicholls (1991) noted that *A. flavipes* was absent from large areas of dry sclerophyll forest in Western Australia with a deep leaf litter. It seems likely that at different sites different habitat components are influencing *A. flavipes*' presence. For instance, Wardell Johnson (1986) suggested that in young forest or recently burnt areas the quantity of invertebrates was a limiting factor, and in older, less disturbed sites the availability of nest sites may be limiting.

Soderquist and Mac Nally (2000) tested the hypothesis that the abundance of mammals was higher in moist gullies than on dry hilltops, slopes and ridges in the Box-Ironbark forests of central Victoria. They found that *A. flavipes* was significantly more abundant in gullies. A greater number of large diameter trees with hollows in gully sites, compared to other topographic areas, is a likely reason for the positive relationship (Soderquist and Mac Nally 2000). Catling *et al.* (2002) modelled the distribution of ground-dwelling mammals in northeastern New South Wales and found *A. flavipes* most commonly on flat to undulating terrain with a north-easterly aspect.

It appears that a number of structural components, influenced by topography, determine the distribution of *A. flavipes*, including large diameter trees, tree hol-

lows, coarse woody debris, rocky crevices and leaf litter. Further research is required to transform this knowledge into information that can be used for the conservation-based management of the species.

Future research into the distribution of *A. flavipes* at the local-scale should focus on:

- providing quantitative information on the habitat requirements of *A. flavipes* for use by natural resource managers. (How deep does leaf-litter need to be? How many hollow bearing trees per hectare are required for nest sites? What are the required loads of coarse woody debris needed? (see Mac Nally and Horrocks (2002) for an excellent example of such research)

- the response of *A. flavipes* to habitat components across different areas of its range. (Which habitat variable is most limiting in each habitat type? Hollow bearing trees? Leaf-litter? Logs? Are responses to habitat variables in floodplain forest similar to those in dry forest and rainforest habitats?)

- the characteristics of hollows used as nest sites

- the effect of introduced predators such as the Red Fox and the Cat, which are likely to be detrimental to a small-mammal species such as *A. flavipes*.

Future Directions

I have highlighted present knowledge of variables that influence the distribution of *A. flavipes*, and shown that many knowledge gaps still remain. How can these knowledge gaps be addressed? Following are some suggestions for future research and examples of experimental designs that may provide useful insights into the distribution of *A. flavipes*.

Multiple scale research

Multi-scale investigations are essential because the processes that determine species distribution patterns change with our scale of investigation; investigations undertaken at only one scale may overlook important patterns (Wiens 1989; Levin 1992; Cooper *et al.* 1998). Wiens *et al.* (1987) suggested that the most likely way to avoid problems of scale is to conduct studies at several hierarchically nested scales, thereby observing different scales

simultaneously. For example, Fischer *et al.* (2003, 2004) investigated the habitat relationships of reptiles at multiple scales using a hierarchical experimental design in a grazing landscape in southern New South Wales. A design consisting of small plots (10 x 10 m) nested within larger sites (equilateral triangles with a 25 m side length) nested within larger landscape units (equilateral triangles with side length of 250 m) allowed both microhabitat and landscape variables to be examined. This design showed that the Four-fingered Skink *Carlia tetradactyla* responded to both landscape variables, such as landscape units with a northerly aspect, and microhabitat variables, such as the abundance of spiders. Hierarchically nested designs offer insights not obtainable from a single-scaled study (Fischer *et al.* 2004) and would provide useful information on *A. flavipes*' distribution and habitat requirements.

Habitat requirements and the effects of fragmentation

Few studies have been undertaken with a focus on the effect of fragmentation on *A. flavipes*, although a number of such studies have been undertaken on its congeners (see Knight and Fox 2000; Wilson *et al.* 2001). Knight and Fox (2000) studied the role of habitat structure in mediating the effects of fragmentation on the abundance of *A. stuartii* in remnant forest in New South Wales. Analysis of remnant vegetation patches of differing size and degree of disturbance indicated that the direct effects of remnant area and disturbance on the abundance of the species were found to be marginal. *A. stuartii* responded more strongly to structural components of the remnant habitat, including understorey height, litter depth and the abundance of logs (Knight and Fox 2000). In turn, these structural characteristics were influenced by the remnant size and degree of remnant disturbance, highlighting that information at one spatial scale can inform what is happening at other scales. Similar research focusing on landscape-scale and local-scale distribution simultaneously is required to further knowledge of the distribution of *A. flavipes*, particularly in regards to habitat loss and fragmentation.

Predictive Modelling

Knowledge of species-habitat relationships and spatial distribution are essential components of effective conservation-based management (Austin 2002; Gibson *et al.* 2004a). The creation of statistical models that correlate the location of species with habitat components by comparing sites where species abundance differs, or where the species is present or absent, can be used to predict species responses (Luck 2002b; Scott *et al.* 2002; Mac Nally *et al.* 2003). These models have been developed for a number of small-mammal species (see Catling *et al.* 2000, 2002; Gibson *et al.* 2004a, b).

For example, Gibson *et al.* (2004b) examined the capability of models to predict the landscape characteristics associated with species richness and the occurrence of small mammals in coastal southwestern Victoria. A negative association between species richness, elevation, habitat complexity and sun index was found. The presence of *A. agilis* was negatively associated with habitat complexity and a sun index, and positively associated with elevation, distance to coast and distance to creeks (Gibson *et al.* 2004b). From these data a predictive distribution model was created, highlighting critical habitat areas, with the potential to guide conservation-based management of a number of mammal species (Gibson *et al.* 2004b). Predictive models based on the habitat relationships of *A. flavipes* would help to guide the management of this species.

Conclusion

A wide range of factors operating over a number of spatial scales influence the distribution of *A. flavipes*. Furthering our understanding of these factors will facilitate improved management of the species habitat and help to secure its long-term conservation.

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History of the FNCV Geology Group, 1880-2005

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Abstract
The history of the FNCV Geology Group from 1880 to 2005 is presented. This includes an account of the origins of the FNCV Geology Group, the geological activities in the early days and the competition with alternative geological forums for members. A case study is given of the involvement of Charles Brittlebank and the FNCV in the elucidation of the Bacchus Marsh glacial sediments. This paper provides detail of notable geological contributors to the FNCV such as TS Hall, Frederick Chapman, ED Gill, Tom Hart, Alf Baker, Jack Douglas, Neil Archbold and Noel Schleiger; it finishes with a description of recent activities of the group under the leadership of Rob Hamson. (*The Victorian Naturalist* **123** (2), 2006, 100-111)

Introduction

Geology as an area of study and recreation has been an integral part of the Field Naturalists Club of Victoria (FNCV)'s history since its foundation in 1880, although a separate geology group was not formed until 1946. This paper was written for the Club's 125th Anniversary celebrations in 2005 and does not attempt to be exhaustive. Reviews of the history of the Club have periodically been published in *The Victorian Naturalist* at key anniversary dates, i.e. 25th (Barnard 1906), 40th (Barnard 1920), 50th (Barnard 1930), 60th (Pescott 1940), 70th (Coghill *et al* 1950) and 100th (Willis *et al* 1980).

Along with Jim Willis's general review of the Club for the Centenary celebrations (Willis 1980) there was a review of the Geology Group by Edmund Gill (1980). Information on past geological activities can be obtained from this review and from an earlier review by Neil (1950). Further information can also be gleaned from the general reviews mentioned above as well as from the collective pages of *The Victorian Naturalist* itself.

Origins of the FNCV

During the 1870s and 1880s there was a noticeable groundswell in the desire for new cultural institutions in the burgeoning Colony of Victoria. The obvious reason for this was that there had been an abrupt increase in population and prosperity as a result of the gold rush of the 1850s. Victoria was flooded with people from Europe and Asia. As the population grew so did the people's demand for services, infrastructure and institutions similar to those available in their countries of origin. By the 1870s and 1880s income per capita in Victoria was one of the highest in the world. It was a period of great confidence and optimism, and of considerable vitality and innovation. Most of the new organisations were modelled on familiar existing British institutions.

In Victoria in the 1850s these developments initially led to the establishment of a range of societies across the intellectual spectrum. Some were more enduring than others. Scientific societies were formed, such as the Philosophical Society of Victoria and the Victorian Institute for the